Overlaying Properties of Particleboard Made from Eastern Redcedar

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Surface finishing and overlaying of wood composite panels such as fiberboard and particleboard improve their appearances and properties resulting in value-added products. It is important to have fine particles on the faces of the panel so that any irregularities on the surface will not show through melamine impregnated thin papers or other kind of overlays. This fact sheet summarizes some of the findings of an experimental study related overlaying and surface roughness of particleboard manufactured from whole-tree chip of eastern redcedar.

Eastern redcedar (*Juniperus virginiana* L.) is one of the widely distributed indigenous conifers in Oklahoma. Over eight million acres of Oklahoma lands are infested with redcedar, primarily in the eastern part of the state. However, in recent decades the trees have begun to take over the tall grass prairies and plains lands of north central and western Oklahoma. Use of low quality eastern redcedar as a raw material in lumber manufacturing is not substantial due to its low value and irregular growth pattern. Therefore, eastern redcedar is a nuisance to farmers and ranchers who often lose crop and pasture land to the species. Many wildlife species that need open range also are affected negatively by this species (1,2,7,10). Eastern redcedar tends to be very aggressive in areas where naturally occurring range fires have been suppressed. Although most of western Oklahoma's eastern redcedar is of poor quality, range-grown trees are not efficient for lumber manufacturing, while some of eastern Oklahoma's forested lands produce redcedar suitable for lumber production (3,4,11,12).

It is important to quantify surface roughness of the panel to have a better overlaying of the substrate. The surface roughness of particleboard could readily be determined in technical terms, given a representative graphical or numerical reading of the surface topography. Several methods are available but have not found wide spread use in the industry, nor have any practical standard of surface quality evaluation of wood composites been developed. Standard contact measuring devices employing a stylus tracer, such as used in the metal and plastic industry was successfully used to evaluate roughness characteristics of various wood composites (5,6,8,9). One of the main advantages of the stylus method is to have actual profile of the surface and standard numerical roughness parameters which can be calculated from the profile. Any kind of irregularities and magnitude of show-through on the overlaid substrates can objectively quantified. Therefore, in this study single and three-layer samples of particleboard panels made from whole-tree chip furnish of eastern redcedar were overlaid and their roughness properties were evaluated using a stylus method to have a better understanding overlaying quality of the samples.

Methods

Three Eastern redcedar trees with an average of 11-inch diameter breast height were harvested in Goldsby, Oklahoma for single-layer panels. Two of the trees were limbed and only their trunks were chipped while the third tree was chipped with branches and foliage using a commercial chipper after they were bucked into smaller segments. The chips were reduced into particle in a laboratory type hammermill without any screening. Later the furnish was dried to 5 percent moisture content in a 30 cubic feet capacity dryer.

Seven low quality eastern redcedar trees with an average breast height diameter of 5 in. (12.7 cm) were harvested at same location were used for three-layer panel manufacture. All of the trees were chipped with branches and foliage using a commercial chipper before the chips were reduced into smaller particles using a laboratory-scale hammermill. Similar to single-layer furnish, whole-tree furnish was dried to 5 percent moisture content. Dried particles were classified into two size categories — fine and coarse — on a 20 mesh screen. Coarse particles were used for the core layer of the three-layer particleboard while the fine particles were used for the face layers of the board. For each panel, 1,520 g coarse and 1,012 g fine particles were blended with urea formaldehyde (UF) resin rotating drum type mixer to form a mix with a solid content of 65.8 percent. Based on oven dry particle weight, 6 percent and 9 percent UF resin were applied using an atomizing spray gun for the core and face layers, respectively. The single-layer furnish for each panel was mixed with 7 percent resin based on oven-dried particle weight and no wax was used in both types of panels. Single-layer panels were made with average target density levels of 0.65 g/cm^3 and 0.75 g/cm^3. Formed panels were pressed in a computer controlled press at a temperature of 385°F and a pressure of 780 psi for five minutes.

Ten samples with the size of 3 in x 5 in were cut from each type of panel for the experiments. Properties and details of panel manufacturing are described in previous studies (3,4). The specimens were conditioned in a room with 55 percent relative humidity and 70°F before they were overlaid. A 6 in x 6 in Carver hand press was used for overlaying process as shown in Figure 1. Both surface of each sample were covered with melamine impregnated paper with 124g/m^2 weight and pressed using a pressure of 350 psi and a temperature of a 320°F for 45 seconds. A combination of stainless steel printing press cauls with mirror-like surface facing the overlays and 0.1 in thick steel cauls were used during the pressing. The specimens were conditions at 55 percent relative humidity before initial surface roughness measurements were taken from their surfaces. Figure 2 shows two types overlaid particleboard samples.

Detroit Precision T-500 stylus unit used in this study consists of the main unit and the pick up model TkE. The pick up has a skid type diamond stylus with 5 µm tip radius and a 90 degree tip angle. The stylus traverses the surface at constant speed of 1 mm/sec over 0.6 in (15.2 mm) tracing length, covering the vertical displacement of the stylus into an electrical signal. A presentation of the surface can be obtained in the form of a graph as illustrated in Figure 3. The calibration of the instrument was checked every 100 measurements by using a standard reference plate with R_a values of 3.02 µm and 0.48 µm. A cut-off length of 0.10 in (2.54 mm), a parameter that differentiates roughness and waviness profiles from each other was used for the test (8).

Fourteen roughness measurements were randomly taken from both sides of each overlaid sample over 0.6 in (15.2 mm)

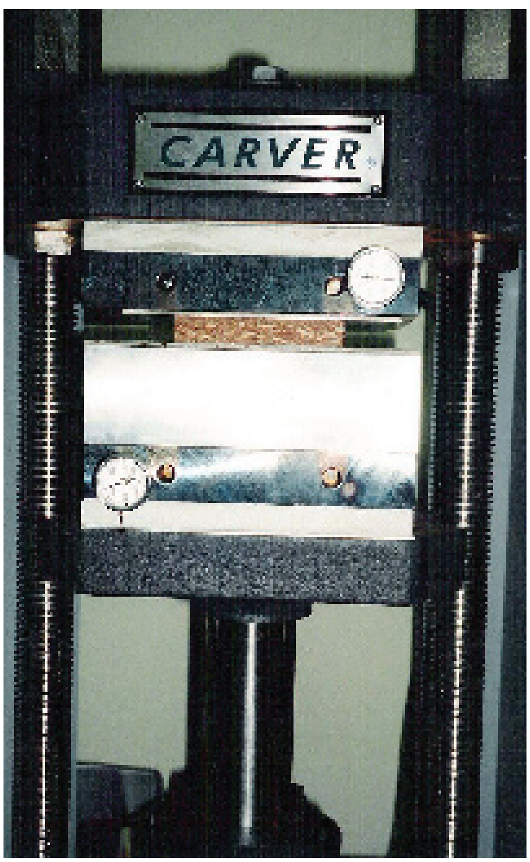

Figure 1. Overlaying process of the samples.

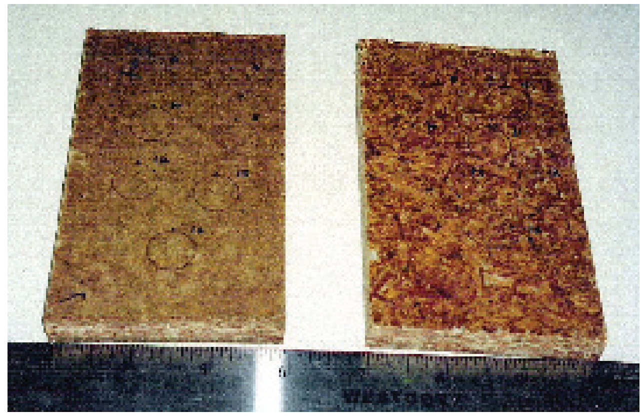

Figure 2. Single-and three-layer overlaid samples.

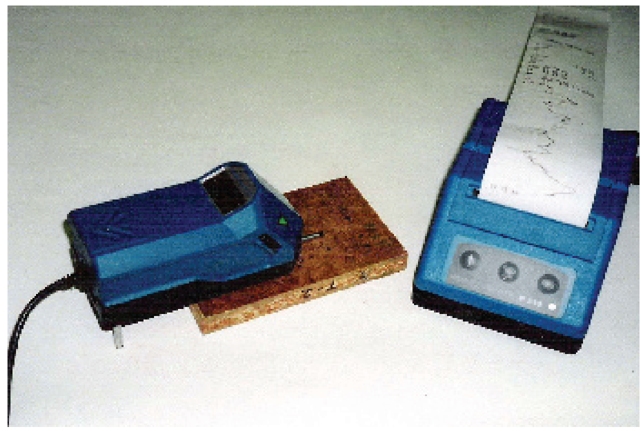

Figure 3. Stylus equipment and roughness profile.

tracing length using the profilometer. After initial measurements were taken at 50 percent relative humidity samples were placed in a conditioning chamber at 92 percent relative humidity and 70°F until they reached equilibrium moisture content. Measurements were repeated from the same location on the samples at this condition. A typical comparison of roughness profiles of the samples taken at 55 percent and 92 percent relative humidity is shown in Figure 4.

Results

It was found single-layer panels manufactured using various types of furnishes did not have significant difference in three roughness parameters at initial exposure. However, three- and single-layer panels showed significant difference in three parameters determined at initial condition Average R_a ,R_z , and R_{max} values of panel types A, B , and C were 1.83µm, 14.34µm, and 21.48µm, respectively. Corresponding values of these parameters obtained form the surface of three-layer specimens were 1.09µm, 7.81µm, and 9.93µm. The strong effect of particle size on the face layer of three-layer specimens was determined as low values of R_a ,R_z ,and R_{max} parameters. When all of the samples were exposed to 92 percent relative humidity their surface characteristics changed which can be visually noticed. Telegraphing effect of irregularities on the surface was clearly quantified by numerical values obtained from the stylus equipment. R_a ,R_z , and, R_{max} of the surfaces exposed to 92 percent relative humidity increased ranging from

1.43 to 5.00 times higher than to those of surfaces conditioned at 55 percent relative humidity. For example R_a and R_{max} panel type of B increase from 1.28μm to 10.61μm and 17.18μm and 29.33μm, respectively. This increase was less prominent in the case of three-layer panels due to fine particles and higher resin content used on the face layers. Such increases in the parameters were also confirmed from the statistical analysis resulting in significant difference between measurements taken at the initial and the final condition for all four types of specimens as shown in Tables 1 and 2. Three-layer samples did not have any delamination of the overlay as a result of high humidity exposure. As similar trend was also observed for single-layer panels made from furnish with and without foliage. Eastern redcedar has approximately 3.8 percent oil and this oil may have acted as plasticizer when a combination of heat and pressure was used during the overlaying process.

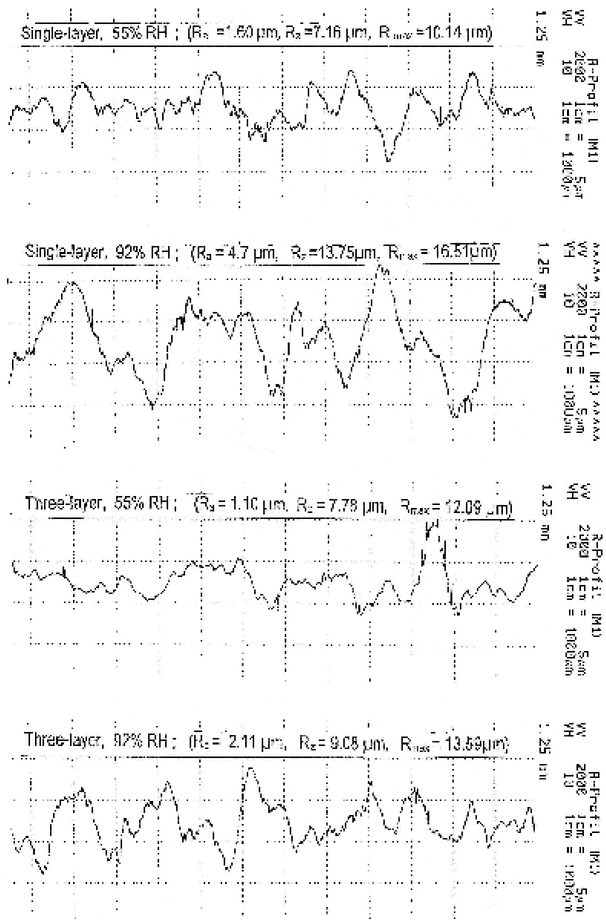

Figure 4. A typical comparison of roughness profiles of the sample taken at 55 percent and 92 percent relative humidity levels.

Conclusions

The study shows that particleboard panels made from whole tree furnish of eastern redcedar can easily be overlaid with melamine impregnated paper. Based on the roughness measurement in this work three-layer panels are ideal for overlaying or any other further application on substrate. It appears that both single- and three-layer panels did not show any deterioration and delamination as a result of high humidity exposure. Overlaying of such panels would provide a value added economical incentive to convert a land management problem into marketable panels which can be used as raw material in furniture and cabinet industry.

Acknowledgement

This study was funded by the Food and Agricultural Products Research and Technology Center, Oklahoma State University. Help in raw material supply by the State of Oklahoma, Department of Agriculture, Central and western Area Headquarters is also acknowledged.

Table 1. Average surface roughness results determined by stylus type profilometer.

Panel Type	Raw material	Sample Number	Roughness Number	Density (g/cm³)	55 % Relative Humidity R_a (μm)	R_z (μ m)	R_{max} (μm)	92% Relative Humidity R_a (μm)	R_z (μm)	R_{max} (μm)
(A) Single-layer	particle with foliage	10	14	0.66	2.15 (22.3)*	19.04 (23.6)	26.71 (19.9)	5.67 (26.6)	28.22 (25.8)	40.23 (24.7)
(B) Single-layer	particle w/o foliage	10	14	0.74	1.28 (31.4)	10.65 (32.8)	17.81 (22.7)	10.61 (33.4)	20.79 (27.6)	29.23 (30.5)
(C) Single-layer	particle with foliage	10	14	0.65	2.07 (24.1)	13.35 (29.9)	20.55 (18.9)	10.36 (26.2)	23.70 (29.5)	34.50 (33.4)
(T) Three-layer	particle with foliage	10	14	0.70	1.09 (14.7)	7.81 (10.6)	9.92 (17.2)	2.34 (19.3)	11.11 (16.4)	16.67 (20.3)

* Numbers in parentheses are COV.

Table 2. Analysis of variance for roughness parameters.

Main Effect	Roughness Parameters	Sum of squares	Degree of freedom	Mean square	F-ratio	p-value
Panel type	R_a	148.03	3	49.39	13.61	0.0692
	R_z	1.397	3	0.466	3.30	0.2414
	R_{max}	478.34	3	159.45	66.62	0.0148
Relative humidity	R_a	183.37	1	183.73	50.56	0.0192
	R_z	13.44	1	13.44	95.11	0.0104
	R_{max}	220.22	1	220.22	92.01	0.0107
Residual	R_a	7.25	2	3.62		
	R_z	0.28	2	0.141		
	R_{max}	4.78	2	2.39		
Total	R_a	434.91	6			
	R_z	19.27	6			
	R_{max}	849.13	6			

R_a: Average roughness, R_z: Mean peak to valley height, R_{max}:Maximum roughness

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Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Robert E. Whitson, Director of Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 42 cents per copy. 0605